

ETHOLOGY OF *MACHIMUS CALLIDUS* WITH INCIDENTAL
OBSERVATIONS ON *M. OCCIDENTALIS* IN
WYOMING (DIPTERA: ASILIDAE)^{1,2}

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It is not unusual to find several different species of Asilidae occurring in the same habitat during the same season. However, we have observed very few species within the same genus that occupy a given ecological niche simultaneously. Species belonging to the genera *Asilus* and *Efferia* are the only ones which we have previously observed, whose adult populations have overlapped in the same habitat. Thus, it was with great interest that we found two species of *Machimus*, *M. callidus* (Williston) and *M. occidentalis* (Hine), occurring together in a habitat 1.6 km east of Laramie, Wyoming, at an elevation of 1625 m above sea level.

This short-to-mid grass habitat was previously described during a study of *Leptogaster parvoclava* Martin (Dennis and Lavigne, 1976b) (Fig. 1). Both *M. callidus* and *M. occidentalis* were found scattered over a 4- to 6-ha area. However, they were generally associated with areas of dense sagebrush (*Artemisia tridentata* Nutt.). Only rarely were they observed to venture out into the more open areas covered primarily by grass (e.g., sandberg bluegrass, *Poa secunda* Presl. and western wheatgrass, *Agropyron smithii* Rydb.) or prickly pear cactus (*Opuntia polyacantha* Haw.). The association of these asilids with sagebrush suggests that they have adapted to the high winds and frequent weather changes typical of the Laramie area.

During the period 1973 to 1976, *M. occidentalis* was collected from June 26 to July 21, whereas *M. callidus* was collected between June 24 and July 28. Although these two species had almost identical seasonal occurrences, there were approximately 25 times as many *M. callidus* collected as *M. occidentalis*.

Foraging and Feeding Behavior

As has been observed for other species of Asilidae (Dennis and Lavigne, 1975; Lavigne and Holland, 1969), *M. callidus* and *M. occidentalis* foraged



Figs. 1, 2. Fig. 1. Habitat of *Machimus callidus* 1.6 km east of Laramie, Wyoming. Fig. 2. Female *Machimus callidus* with *Leptogaster parvoclava* Martin as prey.

from both soil and vegetation depending upon the temperature of the soil surface. Early in the morning and in the late afternoon, these species foraged from the soil. Between forage flights and while feeding, the asilids often flattened themselves against the ground or positioned their bodies at right angles to the sun and elevated the side which was towards the sun. Since asilids, like other insects, are poikilotherms, these positional changes help them maintain an optimum body temperature. Once the soil surface temperature exceeded 28 to 31°C, *M. callidus* moved onto vegetation and foraged from there. However, a few individuals were observed to forage briefly from the soil, even when the surface temperature exceeded 38°C.

While resting on vegetation, *M. callidus* often maintained a position in the shade 12.5 to 30 cm above the ground, but when the sun was obscured by clouds, it would flatten itself against the vegetation or move onto the ground and assume a flattened position. Similar behavior was exhibited when the wind gusted in excess of 24 to 32 km/hr.

Machimus callidus was not observed to forage for extended periods of time from the same site. It would either change foraging sites every 3 to 20 minutes or land on a different site following each forage flight. When this species changed its foraging site, it generally flew in a straight path 17.5 to 30 cm above the ground. This flight height was reduced to 10 to 12 cm when the wind blew in excess of 16 to 24 km/hr.

Between forage flights, *M. callidus* and *M. occidentalis* both exhibited a foraging attitude or posture with their body held at a 45° angle to the substrate upon which they were resting. It is assumed that such a position allowed the asilids to observe more clearly potential prey with the central ommatidia of their eyes. Melin (1923) noted that the central ommatidia have greater powers of vision than do the outer ommatidia.

When engaged in foraging, *M. callidus* frequently made orientation flights about its foraging site. These flights were not directed at potential prey, but presumably were conducted so that the asilid could change its field of vision and/or more clearly orient to its surroundings. Similar flights of this type have been observed for other species of Asilidae (Dennis and Lavigne, 1975; Melin, 1923; Scarbrough and Norden, 1977).

Machimus callidus also made numerous investigatory flights during which it would fly up to investigate potential prey or chase insects without coming into contact with them. These flights covered distances within a 60 to 90 cm radius of an asilid's foraging site. Most prey, however, were successfully captured at a closer distance, usually within 30 to 45 cm of the site. This species was even observed to make investigatory flights with prey impaled on its hypopharynx. However, it was never observed to drop the insect it was feeding on in order to capture another victim. The tendency for individuals to continue to make investigatory flights, while feeding, may indicate an extremely high hunger level.

The distances over which *M. callidus* foraged varied with the time of day. Short forage flights of less than 30 cm were usually made prior to 10:00 AM. Thereafter, longer flights were initiated. This change in flight pattern may be related to increases in soil surface and air temperatures, or to increasingly favorable light conditions. Environmental conditions have been shown to have a significant effect on asilid behavior patterns (Adamovic, 1963a; Dennis and Lavigne, 1975; Lavigne and Holland, 1969; Scarbrough and Norden, 1977).

All prey were captured in flight, 7.5 to 45 cm above the ground, and at various positions around *M. callidus*' foraging site. This species, whether on the ground or vegetation even captured prey which were flying behind it. Such behavior indicates an extremely wide field of vision, which allows an asilid to react to movement of potential prey flying behind its position. Melin (1923) observed *M. atricapillus* Fabr. making "capture-flights" about 30 cm behind its foraging position.

Prior to landing, *M. callidus* inserted its hypopharynx into the captured prey without manipulating them. However, a few individuals were observed to manipulate the prey with all six tarsi during a hover and then insert their hypopharynx before landing to feed. Asilids capturing larger prey fell to the ground and held onto the prey with all six tarsi while inserting their hypopharynx. *Machimus callidus* initially inserted its hypopharynx in the dorsal surface of the prey's thorax. We rarely observed this species initially inserting its hypopharynx between the prey's head and thorax, thorax and abdomen or in the abdomen as does *M. atricapillus* (Melin, 1923).

Attacked insects were not always fed upon. Numerous individuals were observed to capture and release insects without manipulating them or to briefly manipulate them. This behavior was commonly exhibited when Coleoptera, such as *Dichelonyx backii* Kirby, were encountered. It is assumed that prey were released because the asilids were unable to insert their hypopharynx through the prey's cuticle or the prey were unpalatable. Since some prey were released when they exhibited thanatosis, continuous movement of the prey during capture also may be necessary before *M. callidus* will insert its hypopharynx.

Immediately after the hypopharynx was inserted, most prey became immobilized. However, if the hypopharynx was inserted in the prey's abdomen, some prey did not become immobilized for 30 to 60 seconds. Moreover, larger prey, such as *Eucosma* spp. (Olethreutidae), required a longer time for the toxin to become effective.

While feeding *M. callidus* and *M. occidentalis* hovered above their feeding site and manipulated the prey with all six tarsi. Prey were generally manipulated one to three times, depending upon the size of the prey. All asilid behavior studies to date indicate that hovering and manipulating prey

above the feeding site is most common among species in the subfamily Asilinae (e.g., see Dennis and Lavigne, 1975; Lavigne and Holland, 1969).

As has been reported for other species of Asilidae (Dennis and Lavigne, 1975, 1976a; Lavigne and Holland, 1969; Lavigne et al., 1976), *M. callidus* exhibited abdominal pumping and subsequent ballooning of the prey. This was commonly seen when small Diptera and Hymenoptera served as prey. These phenomena are associated with the asilids pumping in digestive enzymes and pumping out digested material.

Machimus callidus fed on prey for an average of 19 minutes 33 seconds, with a range between 1 minute 30 seconds and 77 minutes (Fig. 2). As is frequently found among Asilidae, the length of the prey was positively correlated with the time spent feeding. Small prey, such as *Empoasca* sp. (Cicadellidae), with an average length of 1.5 mm were fed on for less than 3 minutes; whereas larger prey, such as *Serica anthracina* Le Conte (Scarabaeidae) with an average length of 5 mm, required 24 to 28 minutes. The longest feeding period (77 minutes) occurred when a copulating female continued to feed on a *S. anthracina* throughout the mating.

Interfeeding times varied between 8 and 65 minutes, with an average of 28 minutes 17 seconds. *Machimus callidus* foraged most actively in the morning and during this time shorter interfeeding times occurred. In the afternoon, this species spent most of its time resting in the shade or seeking shelter from early afternoon storms, rather than foraging.

At the completion of feeding, prey were discarded in one of three ways: (1) they were pushed off the asilid's hypopharynx with the fore tarsi while the asilid was still at the feeding site; (2) an asilid dropped its prey in flight as it moved to a new location and/or resumed foraging; and (3) the asilid retracted its hypopharynx into the labium and the prey was allowed to slip off the hypopharynx at the feeding site. The first two methods were most commonly observed for *M. callidus*.

This species was approximately 2.4 times as large as its prey (Table 1). Females were slightly larger than males and also fed on slightly larger prey.

Both sexes of *M. callidus* fed on the same orders of prey. However, males fed on a larger percentage of Coleoptera and Diptera (Table 2), while females were less selective and fed on almost equal percentages of Coleoptera, Diptera, Homoptera and Hymenoptera. Both males and females appeared to be opportunistic predators, preying quite heavily on winged *Formica* sp. and *Serica anthracina*, when these insects would suddenly appear en masse. Similar behavior has been observed for other species of *Machimus* (Adamovic, 1963a and b), *Ospricerus latipennis* (Loew) and *Stenopogon inquinatus* Loew (Dennis and Lavigne, 1975).

Melin (1923) and Poulton (1906) observed *M. atricapillus* feeding on Diptera and Homoptera. Parmenter (1941, 1942, 1952) indicated that prey of

Table 1. Relation between length of *Machimus callidus* and that of its prey.

Sex	Predator length (mm) ¹			Prey length (mm)			No. of prey measured	Mean ratio of predator to prey
	Mini- mum	Maxi- mum	Mean	Mini- mum	Maxi- mum	Mean		
Male	13.2	15.6	14.5	1.5	16.0	6.3	60	2.3
Female	12.5	16.0	14.8	1.5	14.5	6.1	80	2.4
Unidentified ²	—	—	—	6.0	9.5	7.2	8	—
	12.5	16.0	14.7	1.5	16.0	6.2	148	2.4

¹ 10 predators of each sex were measured.
² Unidentified indicates that the sex of the predator was not determined.

that species belong to the Orders Coleoptera, Diptera, Hemiptera, Hymenoptera and Lepidoptera. Lundbeck (1908) added *Homalomyia scalaris* to previous listings of prey species. Adamovic (1963a and b) made a detailed analysis of the prey of several species of *Machimus* in Yugoslavia. He found that these asilids, like *M. callidus*, fed primarily on Coleoptera, Diptera and Hymenoptera. However, some species also took a large number of Lepidoptera. Additionally, insects in the Orders Odonata and Orthoptera were taken, which we did not observe for *M. callidus*. Differences in prey selection relate to prey availability, seasonal occurrence of both predator and prey, prey density, and, perhaps, species preference.

The following is a list of prey taken by *M. callidus*. Since specific identifications are not available for all specimens, some prey were identified

Table 2. Number and percent composition of different orders of prey taken by *Machimus callidus*.

Order	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
Coleoptera	16	26.2	18	20.2	37*	23.4
Diptera	18	29.5	15	16.9	35*	22.2
Hemiptera	1	1.6	3	3.4	5*	3.2
Homoptera	9	14.8	14	15.7	23	14.6
Hymenoptera	12	19.7	22	24.7	36*	22.8
Lepidoptera	5	8.2	15	16.9	20	12.7
Neuroptera	0	0.0	2	2.2	2	1.3
	61		89		158	

* Includes 3 Coleoptera, 2 Diptera, 1 Hemiptera, and 2 Hymenoptera for which the predator sex is unknown.

only to family or genus. The number and sex, if known, of the predator is indicated in parentheses following the prey recorded. We wish to acknowledge the efforts of the following taxonomists who identified the prey insects: W. D. Duckworth (Yeponomeutidae), O. S. Flint (Hemorobiidae), R. C. Froeschner (Nabidae), R. J. Gagne (Cecidomyiidae), R. D. Gordon (Scarabaeidae), J. L. Herring (Miridae), R. W. Hodges (Gelechiidae), L. V. Knutson (Bombyliidae), J. P. Kramer (Cicadellidae, Margarodidae), A. S. Menke (Sphecidae), C. W. Sabrosky (Tachinidae), D. R. Smith (Formicidae), G. C. Steyskal (Trupaneidae), F. C. Thompson (Dolichopodidae), and W. W. Wirth (Chironomidae) of the U.S. Systematic Entomology Laboratory, D. R. Davis (Lyonetiidae, Olethreutidae) of the National Museum of Natural History, Smithsonian Institution, and F. A. Lawson (Culicidae), of the Entomology Section, University of Wyoming.

COLEOPTERA, Scarabaeidae: *Dichelonyx backii* Kirby, VII-8-73 (2 ♀, ♂), VII-9-76 (♀), VII-12-76 (2 ♀), VII-15-73 (4 ♀), VII-16-73 (2 ♂); *Serica anthracina* LeConte, VI-26-74 (♀), VII-3-73 (♀, ♂), VII-4-73 (♀), VII-5-73 (4 ♀, 2 ♂, sex unknown), VII-6-73 (3 ♀, 2 ♂), VII-7-73 (3 ♂, 2 sex unknown); *Serica* sp., VI-24-72 (♂), VI-26-72 (♂), VII-5-73 (♂), VII-7-73 (♂); DIPTERA, Asilidae: *Leptogaster parvoclava* Martin, VII-4-73 (3 ♂), VII-5-73 (♂), VII-5-74 (♂), VII-7-73 (♀), VII-8-73 (3 ♀, sex unknown), VII-15-73 (2 ♀, ♂), VII-17-73 (♂); *Machimus callidus* (Williston), VII-6-73 (♂), VII-8-73 (♀); Bombyliidae: *Phthiria* sp., VII-17-73 (♂), Cecidomyiidae: Cecidomyiidi, VI-26-72 (♀); *Neolasioptera* sp., VII-5-73 (♀); Chironomidae: unidentified, VII-4-73 (♀), VII-18-73 (♀); Culicidae: *Aedes dorsalis* (Meigen), VII-5-73 (♂), VII-6-72 (sex unknown), VII-7-73 (♂), VII-15-73 (♀), VII-16-73 (♂), VII-17-73 (♂); *Aedes idahoensis* (Theobald), VII-24-72 (♂), VI-26-72 (♀, ♂); Dolichopodidae: *Medetera* sp., VI-25-72 (♀), VII-2-73 (♂); Tachinidae: *Gonia albagenae* Morr., VII-4-73 (♂); Trixoscelididae: *Trixoscelis fumipennis* Melander, VII-5-73 (♀); Trupaneidae: *Paracantha culta* (Wied.), VII-17-73 (♂); HEMIPTERA, Miridae: *Coquillettia insignis* Uhler, VI-30-74 (sex unknown), VII-8-73 (♂), VII-12-73 (♀); *Europiella* sp. prob. *stigmada* (Uhler), VII-12-76 (♀); Nabidae: *Nabis alternatus* Parshley, VII-8-73 (♀); HOMOPTERA, Cicadellidae: *Empoasca neaspersa* Oman & Wheeler, VII-3-73 (♀), VII-5-73 (♀, ♂), VII-8-73 (♂), VII-12-73 (♂), VII-16-73 (♀); *Empoasca nigra* var. *typhlocyboides* Gillette & Baker, VII-5-73 (♂), VII-6-73 (♀); *Empoasca* sp., VI-26-72 (♀, ♂), VI-26-74 (♂), VII-10-72 (♀); Cicadellidae (Euscelidae): *Balclutha neglecta* (DeLong & Davidson), VII-4-73 (2 ♀), VII-6-73 (♀), VII-7-73 (♀), VII-8-73 (♀), VII-15-73 (♀, 2 ♂), VII-16-73 (♀); *Mocuellus collinus* (Boh.), VII-15-73 (♂); Margarodidae: *Margarodes* sp., VII-10-72 (♀); HYMENOPTERA, Chalcidoididae: unidentified, VI-24-72 (♀), VII-5-73 (♀); Formicidae (all winged reproductives): *Formica* sp., VII-3-73 (♀, 2 ♂), VII-5-73 (2 ♀), VII-7-73 (♂), VII-9-73 (♀, sex unknown), VII-9-76 (♂), VII-11-73 (♀), VII-12-73 (♀), VII-12-76

(♀), VII-14-74 (2 ♂), VII-14-76 (♂), VII-15-73 (3 ♀, 2 ♂, sex unknown), VII-18-73 (8 ♀, 2 ♂, sex unknown), VII-28-74 (♂): *Tapinoma sessile* (Say), VII-3-73 (♀); Sphecidae: *Solierella* sp., VII-3-73 (♂); unidentified, VI-27-74 (♀); LEPIDOPTERA, Gelechiidae: unidentified, VII-17-73 (♀); Lyone-tiidae: *Bucculatrix* sp., VII-3-73 (♂); Olethreutidae: *Eucosma propana* Kft., VII-12-73 (3 ♀), VII-14-76 (♀, ♂), VII-15-76 (♀), VII-19-76 (♂); *Eucosma* sp., VII-7-73 (♀), VII-8-73 (♀); *Eucosma* sp., prob. *propana* Kft., VII-12-76 (♀); *Phaneta* sp., VII-17-73 (♀, ♂); Yeponomeutidae: *Plutella xylostella* (L.), VII-16-72 (♀); Unidentified, VII-28-74 (♀), VI-30-74 (♀), VII-12-76 (♂), VII-15-76 (♀), VII-19-74 (♀); NEUROPTERA, Hemerobiidae: ?*Micro-mus* sp., VII-9-76 (♀); *Sympherobius killingtoni* (Carp.), VII-10-76 (♀).

We have only collected *M. occidentalis* preying on *Leptogaster parvoclava* (VII-15-76, ♂) and a winged reproductive *Formica* sp. (VII-12-74, ♀).

As noted in the prey list, both sexes of *M. callidus* were cannibalistic. On one occasion a male released another male which had exhibited thanatosis. The first male may have mistook the second male for a female and attempted to mate with him or the lack of movement may have interrupted the sequence of events leading up to insertion of the hypopharynx into the second male. Another male was observed to attack a male, releasing him shortly thereafter. The attacked male appeared dead, but after about 30 seconds he groggily crawled onto some prickly pear cactus and flew off. It is assumed that the male was temporarily paralyzed by an injection from the salivary glands of the attacking male, but the toxin injected was insufficient to disable him permanently. Kahan (1964) reported that both *Locusta migratoria* and white mice recovered when injected with small quantities of a salivary gland suspension from *Machimus* sp. and *Machimus rusticus* Meigen.

In addition to cannibalism, *M. callidus* were preyed on by *Stenopogon inquinatus* and a female was pounced on by a salticid spider, *Pellenes americanus* (Keyserling). Asilids which occupy the same habitat frequently prey on each other, and spiders are often observed preying on Asilidae. Melin (1923) also observed red mites on *M. atricapillus*.

Mating Behavior

Mating pairs of both *M. callidus* and *M. occidentalis* were observed. No discernible differences existed between these and mating patterns reported for other species of *Machimus* (Adamovic, 1963a; Melin, 1923).

Matings were initiated without any courtship and no male searching flights were observed. In the six species of *Machimus* that Adamovic (1972) studied, he was unable to discern any courtship or male searching flights, with the exception of *M. rusticus* (Meigen). In this species, "the searching flight of the male is uncertain, irregular, and lasts for a short time."

Prior to copulation, a *Machimus* male would overtake a female in flight, grasp her on the dorsum of her thorax and the struggling pair would fall to the ground where the genitalia would be joined. The asilids then usually flew onto the shaded side of vegetation.

During copulation, both *M. callidus* and *M. occidentalis* remained in the male over female position (Fig. 3). While in this position, the male's abdomen curved around to either the right or left of the female's abdomen and clasped her genitalia from below. The female's wings were generally held parallel to the sides of her abdomen, although sometimes the wings were held closed over her dorsal surface or slightly spread. The male's wings were always folded over his abdomen. The male's fore tarsi rested on vegetation or on the female's eyes, and the male's mid and hind tarsi either rested on the female's thorax and abdomen, respectively, or passed around the female and grasped vegetation.

Mating pairs generally remained in situ, unless disturbed. Then they would fly, maintaining the same mating position, 3 to 5 m to another location on the vegetation and continue copulating. Occasionally in flight, a few mating pairs assumed the tail-to-tail position. However, once they landed, they immediately resumed the male over female position. A behavior commonly reported for *Proctacanthus micans* Schiner (Dennis and Lavigne, 1975) was observed once for *M. callidus*. When a mating pair fell to the ground from the vegetation they were resting on, the male unclasped the female's genitalia. After 30 seconds the male reclasped the female's genitalia and remained in this position for 18 minutes before again unclasping her genitalia. The mating pair were then lost to sight as they flew from the ground onto some vegetation.

These asilids did not exhibit foraging behavior while in-copula; however, females often had prey at the initiation of mating and they continued to feed during the copulatory act.

Nine complete matings were observed for *M. callidus* and three complete matings of *M. occidentalis* were observed. *Machimus callidus* matings took an average of 59 minutes 42 seconds, with a range between 50 minutes 30 seconds and 76 minutes. *Machimus occidentalis* remained in-copula for 52 to 58 minutes, with an average of 55 minutes.

Matings were generally terminated when the male unclasped the female and flew off. However, one *M. callidus* male briefly "pulled-down" on the female's genitalia 7 minutes before the termination of mating and the female rubbed their abdomens and genitalia 3 minutes prior to separation. In addition, a male of this species was observed to "excitedly" buzz his wings just prior to unclasping the female's genitalia.

Male *M. callidus* frequently pursued other males and attempted to mate with them. However, they generally separated shortly after contact. This behavior implies that males of this species must make contact with another



Figs. 3, 4. Fig. 3. Mating pair of *Machimus callidus*. Fig. 4. Female *Machimus callidus* ovipositing in a sagebrush branch crevice.

asilid before being able to determine its suitability as a mate. The initial stimulus for both mating and foraging behavior in this species appears to be movement. Since *M. callidus* is cannibalistic, contact stimuli may play an important role in determining the correct response. Also, size must be important because potential mates are larger than the majority of prey. Other key stimuli may be shape and color of the insect being pursued and whether the male can successfully clasp the other insect's genitalia. Dennis et al. (1975) showed that for *Efferia frewingi* Wilcox, the size, shape and color of prey are used in determining the attack response, based on experiments with models constructed to simulate prey.

Although we only timed 12 complete matings, we saw very few encounters between the sexes that did not result in matings. Adamovic (1963a) also noted that almost all contacts between male and female *Machimus* spp. resulted in mating.

Multiple mating has been observed for other Asilinae. Dennis and Lavigne (1976a) and Lavigne and Dennis (1975) reported that *Efferia frewingi* and *E. varipes* (Williston) mate more than once. We observed similar behavior for *M. callidus* when a male successfully mated twice with two different females.

Oviposition Behavior

While searching for oviposition sites, *M. callidus* females flew onto vegetation, landed with their heads oriented up, curled their abdomens downward, and began to probe with their ovipositors. As the females probed, they crawled around the vegetation and swung their ovipositors from side-to-side in contact with the vegetation.

Females frequently spent several minutes searching for an oviposition site. Once they located a suitable site, they usually deposited one egg over a 15 second to 1 minute period. However, one female deposited three eggs during a similar time period (Fig. 4).

Following an oviposition, females either began looking for another site to deposit eggs or resumed foraging. Females were observed to oviposit as many as five times in succession before being lost to sight or resuming foraging.

Female *M. callidus* oviposited 10 to 30 cm above the ground in the seed heads of grasses, between the sheath and stem of grasses, on a dead snake-weed branch (*Gutierrezia sarothrae* (Pursh) Britt. and Rusby), and in the crevices of sagebrush branches. Females were also observed to use their ovipositors to investigate leaves and buds of sagebrush, tumbleweed (Russian-thistle, *Salsola kali* L.) and live snakeweed branches, however no eggs were deposited in these sites. Successful ovipositions may not have occurred on the latter two types of vegetation because of the lack of crevices



Fig. 5. Eggs of *Machimus callidus* (32 \times).

on these plant parts. Melin (1923) observed *M. atricapillus* depositing eggs in dry "flower-heads" of *Carex* and *Hieracium* spp. The eggs of *M. annulipes* (Brulle), *M. caliginosus* (Meigen), *M. fimbriatus* (Meigen), *M. gonatistes* (Zeller), and *M. rusticus* (Meigen) are laid on the flowers, dry or green, spikes and leaves of grasses and other plants, while those of *M. cyanopus* Loew are laid on fallen leaves of dried fern (Adamovic, 1972).

All deposited eggs are creamy-white and oblong (Fig. 5). The eggs range in length from 0.98 to 1.09 mm, with an average of 1.04 mm. The range in width was from 0.34 to 0.38 mm, with an average of 0.36 mm. Melin (1923) and Parmenter (1952) reported eggs of a similar shape and color for *Machimus* spp.

Grooming Behavior

Machimus callidus and *M. occidentalis* exhibited grooming behavior similar to that described for other species of Asilidae (Dennis and Lavigne, 1975). Grooming of the face was quite common after feeding, whereas grooming of the abdomen and genitalia was usually exhibited following copulation and oviposition.

Daily Rhythm of Activity

Machimus callidus foraged primarily between the hours of 8:00 and 11:00

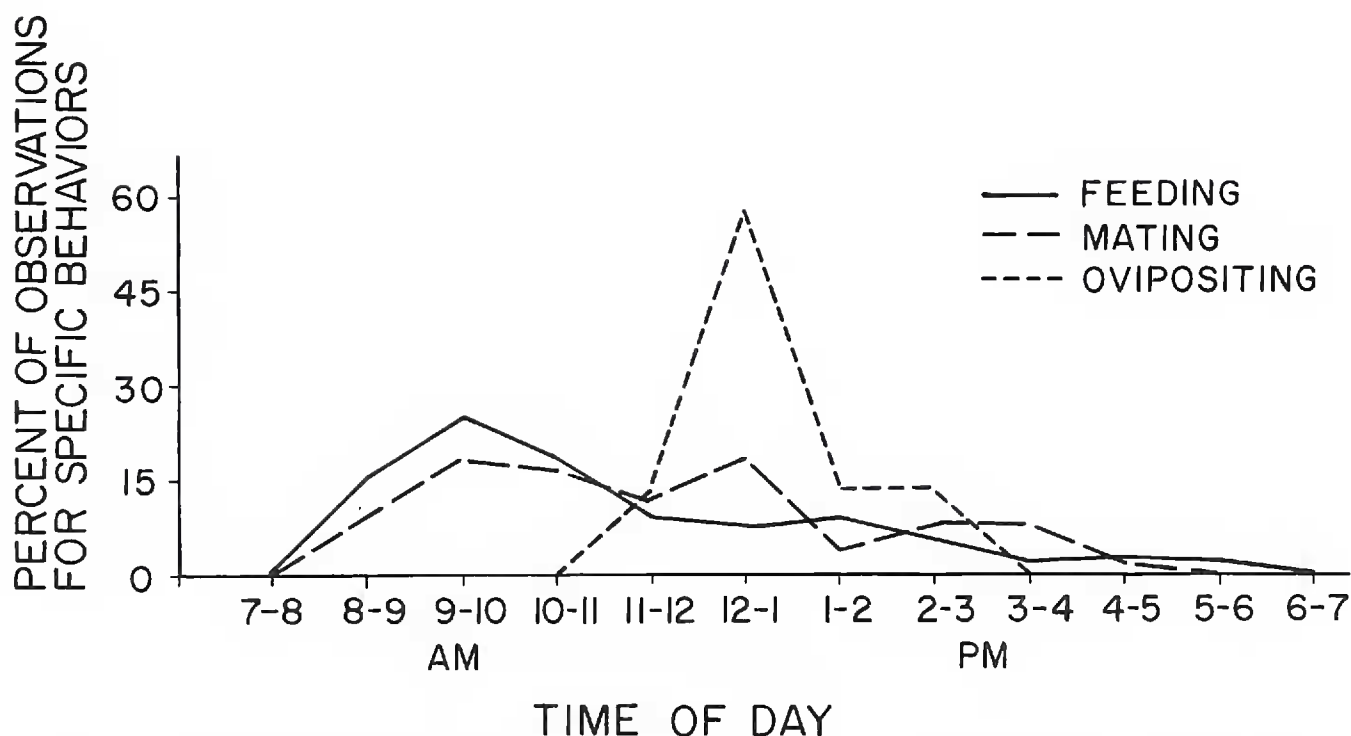


Fig. 6. The diurnal rhythm of activity of *Machimus callidus* (the percent of observations for specific behaviors was calculated based on the total number of observations for each behavior—150, 48 and 7 observations for feeding, mating and ovipositing, respectively).

AM, with a peak period from 9:00 to 10:00 AM (Fig. 6). Most mating pairs were observed during an overlapping time period between 8:00 AM and 1:00 PM. However, two peak periods for mating occurred, one between 9:00 and 10:00 AM and the other between 12:00 noon and 1:00 PM. Most females oviposited concurrently with the latter peak period for mating.

Throughout the period in which *M. callidus* most actively engaged in feeding and mating, the air temperature at their height on the vegetation generally varied between 26 and 35°C. Oviposition occurred when it was slightly warmer with an air temperature between 31 and 36°C.

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Footnotes

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